You have mastered this topic when you can:

1) describe or define these terms: ***chemical reaction***, ***chemical equation***, ***reactants***, and ***products***
2) describe a ***chemical reaction*** in terms of the rearrangement of the atoms as existing bonds are broken and new bonds are formed.
3) describe the ***collision-reaction theory***.
4) observe and record changes that occur during a ***chemical reaction***.

INTRODUCTION TO CHEMICAL REACTIONS

I) Matter is composed of more than 100 different elements that react with each other to form an infinite variety of molecules and compounds. These substances–elements, molecules and compounds–interact together to create new substances–different elements, molecules and compounds–through **CHEMICAL REACTIONS**. ***A CHEMICAL REACTION is an interaction between particles of a single substance or particles of two or more substances that results in the production of one or more new substances having different properties. Chemical reactions*** are described using **CHEMICAL EQUATIONS.**

A) ***A CHEMICAL EQUATION is a shorthand representation of a chemical reaction that includes the chemical formula, states, and number of particles of each substance that reacted together and each substance that is produced.*** By convention, substances reacting together are called ***REACTANTS*** while substances produced are called ***PRODUCTS***. As well, ***chemical equations*** are written with the name or the formula of each ***reactant*** separated by + signs on the left side of an arrow (→) and the name or the formula of each ***product*** separated by + signs on the right side of the arrow. The arrow (→) means: produces, reacts to produce, produced from, yields, yielding, decomposes, creating, making, synthesizes, etc. ***NEVER USE AN EQUAL SIGN (=) BETWEEN THE REACTANTS AND PRODUCTS!!***

Reactants → Products

Word equation: hydrogen gas + oxygen gas → water

Chemical equation: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$

II) ***Chemical reactions*** involve the breaking of bonds holding ***reactant particles*** together, the reorganization of the atoms, and formation of new bonds resulting in the creation of new ***product particles***. Consider the reaction between methane and oxygen gas producing carbon dioxide and water vapour.

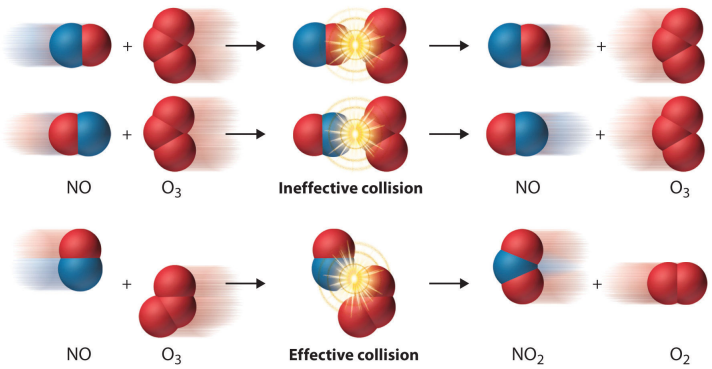
$$CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

A) The methane molecules are held together by four single bonds while oxygen molecules are held together by one double bond. During the chemical reaction all the bonds holding each methane molecule and each oxygen molecule together are broken. This frees the atoms, allowing them to form new bonds resulting in the creation of different particles, the products.

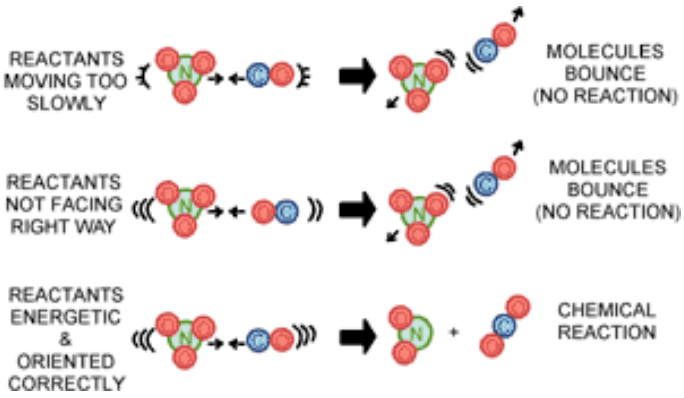
THE COLLISION-REACTION THEORY

I) The **COLLISION-REACTION THEORY** states that all particles of matter are moving. The movement of ***reactant particles*** allows them to collide together. When the collisions have enough force and favourable orientation, bonds holding ***reactant particles*** together are broken, which allows the atoms to be re-arranged resulting in the formation of new bonds creating new ***products particles***.

A) **NOTICE** the difference in collision orientation between the ineffective collision and the effective collision.



B) **NOTICE** the difference between the three collisions in terms of KE, speed of particles, and orientation of particles.



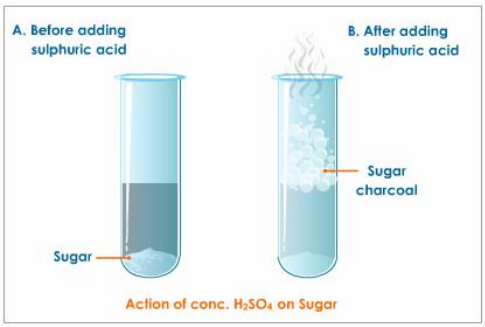
II) When bonds holding ***reactant particles*** together are broken, and atoms are re-arranged allowing for the formation of new bonds creating new ***products particles***, a **CHEMICAL CHANGE** has occurred. ***A CHEMICAL CHANGE is any change in which a new substance is produced.*** Because it is ***impossible to see the bonds*** holding ***reactant particles*** breaking, the re-arranging of atoms and the formation of new bonds creating the ***product particles***, chemists must rely on observable evidence that implies a ***chemical change*** has occurred. In this Topic you will make conduct an investigation that allows you to make observations of several ***chemical reactions*** designed to highlight key pieces of evidence indicating that a ***chemical change*** has occurred.

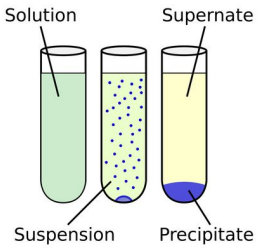
EVIDENCE OF CHEMICAL REACTIONS

I) **EVIDENCE OF A CHEMICAL CHANGE OCCURRING**

A) **REMEMBER:** A new substance can only be formed by the breaking of bonds holding the ***reactants particles*** together so their atoms can be re-arranged allowing for the formation of new bonds creating ***product particles***. There are five ***chemical changes*** described below that provide evidence that a ***chemical reaction*** has occurred.

1) ***A NEW SUBSTANCE IS ALWAYS PRODUCED AS EVIDENCED BY THE FORMATION OF A GAS, SOLID OR LIQUID.*** One or more of the newly formed products usually exists in a different state, often a gas or a solid, than the reactant. The creation of new substances is evidence that bonds in reactant particles have been broken allowing a rearrangement to occur allowing for the creation of new substances called products.



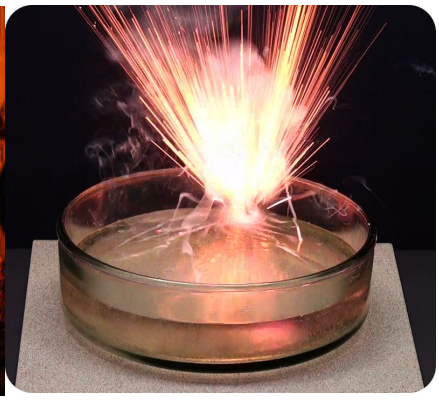


2) ***THE AMOUNT OF ONE OR MORE OF THE REACTANTS DECREASES (IS CONSUMED).*** A denture tablet is completely consumed (used up) when added to water suggesting that it was converted to product particles. This provides evidence that the bonds holding the ***reactant particles*** together have been broken, their atoms re-arranged allowing for the formation of new bonds creating ***product particles***.

3) ***ENERGY IS ALWAYS INVOLVED IN A CHEMICAL CHANGE.***

a) **ENDOTHERMIC REACTIONS** absorb energy: **i.e.** Cooking an egg is an ***endothermic reaction*** because energy in the form of heat or electricity must be supplied from an external source to force the reaction to occur

b) **EXOTHERMIC REACTIONS** release energy: **i.e.** Combustion (burning) is ***exothermic*** because energy in the form of heat, light, and sound is released.



Chemical reactions release or absorb energy.

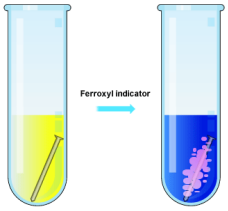
exothermic reactions

endothermic reactions

The reaction in an oxy-acetylene torch is exothermic.

Photosynthesis is an endothermic reaction.

4) ***CHANGE IN COLOUR MAY OCCUR.*** The products may be a different colour than the reactants. This provides evidence that the bonds holding the ***reactant particles*** together have been broken, their atoms re-arranged allowing for the formation of new bonds creating ***product particles***.



5) ***CHANGE IN ODOUR MAY OCCUR.*** Products sometimes have a different odour than reactants. **NEVER SMELL ANY CHEMICAL BECAUSE SOME ARE EXTREMELY HAZARDOUS TO YOUR HEALTH!!**

Evidence of Chemical Change

- the evolution of a gas
- the formation of a precipitate
- the release or absorption of energy
- a change in temperature or the giving off of light energy
- a color change in the reaction system

a When acetic acid, in vinegar, and sodium hydrogen carbonate, or baking soda, are mixed, the solution bubbles as carbon dioxide forms.

b When solutions of sodium sulfide and cadmium nitrate are mixed, cadmium sulfide, a solid precipitate, forms.

c When aluminum reacts with iron(III) oxide in the clay pot, energy is released as heat and light.

d When phenolphthalein is added to ammonia dissolved in water, a color change from colorless to pink occurs.

B) **e.g.** When an egg is cooked, a ***chemical reaction*** occur as evidenced by:
1) Heat *energy* is required to cause the reaction to occur, thus it is an ***endothermic reaction***.
2) A *solid*, a precipitate, forms. The uncooked liquid egg becomes solid when it is heated suggesting a new substance was produced. When the egg cools, it does not return to the liquid state offering further evidence that a new substance was produced.
3) *Colour changes* are observed. The clear portion of the uncooked egg becomes white while the bright yellow yoke becomes dull, chalky yellow suggesting a new substance was produced.
4) The evidence given above indicates the bonds within the ***reactant particles***, the uncooked egg particles, have been broken, their atoms re-arranged allowing for the formation of new bonds creating ***product particles***, the cooked egg particles.

C) **e.g.** Rusting of automobiles is a common ***chemical reaction***. Automobiles rust when $Fe_{(s)}$ in the steel react with $O_{2(g)}$ in the air to produce $Fe(OH)_{3(s)}$ and $Fe_2O_{3(s)}$ as evidenced by:
1) A rust, a flaky reddish orange *solid*, precipitate, is formed suggesting a new substance was produced.
2) *Colour changes* are observed. Grey $Fe_{(s)}$ becomes a reddish brown solid suggesting a new substance was produced.
3) Electrical *energy* is produced, thus the reaction is ***exothermic***.
4) The evidence given above indicates the bonds within the ***reactant particles***, the $O_{2(g)}$ and the $Fe_{(s)}$ particles, have been broken, their atoms re-arranged allowing for the formation of new bonds creating ***product particles***, the rust.

D) **FALSE REACTIONS:** A ***false reaction*** occurs when one or more characteristic ***chemical changes*** are observed but the structure of the ***reactant particles*** have not changed, only their state has changed.
1) **e.g.** Consider the melting of wax. When heated, the solid white waxy substance becomes a clear liquid. Energy is required, and colour change and change of state have occurred, all of which are ***chemical changes*** supplying evidence of a ***chemical reaction***. However, when the hot clear liquid cools, it returns to

the solid white waxy substance indicating the structure of the ***reactant particles*** has not changed, rather they experienced a change of state.

E) **Required Practice 1:** Answer these questions. **{Answers are on page 5.}**

1. List five changes that provide evidence that a chemical change has occurred.
2. For each of the five changes give a household example and explain how it is evidence that a chemical reaction has occurred.
3. When a small piece of solid potassium is added to water, sparks, flame, sound and a colourless gas are generated until the piece of potassium disappears. List all evidence that a chemical change has occurred and explain how each is evidence of the chemical reaction.
4. A solution of copper(I) nitrate is pale green in colour. When sodium chloride is added the solution becomes colourless and a solid appears at the bottom of the beaker. State whether or not a chemical reaction has occurred and justify your choice.
5. Explain the difference between an endothermic reaction and an exothermic reaction using some household examples.
6. Describe the characteristics of a false reaction and how it may be confused as a chemical reaction.
7. List the two characteristics that are different between a chemical reaction and a false reaction.

ANSWERS TO THE REQUIRED PRACTICE

Required Practice 1 from page 5

1. Five changes that provide evidence that a chemical change has occurred are: 1: the formation of a new substance; 2: one or more of the reactants is consumed; 3: energy is used or produced; 4: a colour change may occur; 5: a change in odour may occur. **2.** See your Teacher. **3.** Sparks, flame and sound are produced indicating energy is produced which is evidence that bonds may have been broken then re-formed. A colourless gas is produced indicating a new substance has been produced which is evidence that bonds may have been broken then re-formed. The piece of solid potassium disappears indicating that one of the reactants was consumed which is evidence that bonds may have been broken then re-formed. **4.** This is a chemical reaction because a colour change and a new solid is formed indicating a new substance was produced. **5.** An endothermic reaction is one that requires energy be added to the reactants in order for it to occur. **i.e.** Cooking a double chocolate cake. An exothermic reaction is one that produces energy. **i.e.** Burning wood in the fire place. **6.** The characteristics of a false reaction include energy being used, colour changes may occur, a change in state may occur. False reaction may be confused with chemical reactions because their characteristics are also indicators of chemical reactions. **7.** A chemical reaction involves one or more reactants being consumed and one or more new substances being produced. A false reaction does not consume a reactant nor does it produce a new product.

ASSIGNMENT

At the top of your assignment, please print **"T28 – Evidence of Chemical Reactions", your LAST then First name, block and date**. Complete these questions in the order given here. *[Marks indicated in italicized brackets.]*

1. Describe the Collision-Reaction theory. *[4]*
2. According to the Collision-Reaction Theory, under what circumstances would a collision between reactants not occur? *[2]*
3. When Alka-Seltzer tablet is placed in to a glass of water, bubbles are produced and the tablet eventually disappears. Is this a chemical or physical change? Justify you answer. *[3]*
4. The internal combustion engine found in most cars is designed to convert liquid gasoline to the gas phase. Use the Kinetic Molecular Theory to explain how gaseous gasoline is available for combustion in an engine. *[2]*
5. Chlorine is an extremely important element that is used in many products as a disinfectant or in a cleaning product such as household bleach. About 95% of the chlorine used to create these products comes from the electrolysis of brine solutions, solutions containing NaCl. The net reaction shows that aqueous sodium chloride reacts with water to produce chlorine gas, hydrogen gas and aqueous sodium chloride.
   a) Write a word equation to represent the chemical reaction. *[5]*
   b) Suggest reasons why this reaction must occur in a sealed container. *[2]*
   c) What evidence of a chemical change would you expect to observe. *[2]*
   d) Classify each reactant and product as an ionic compound, a molecular compound or a molecular element. *[5]*
   e) Which of the substances in the reaction can be classified as polar molecules. *[1]*

[26 marks in total]